

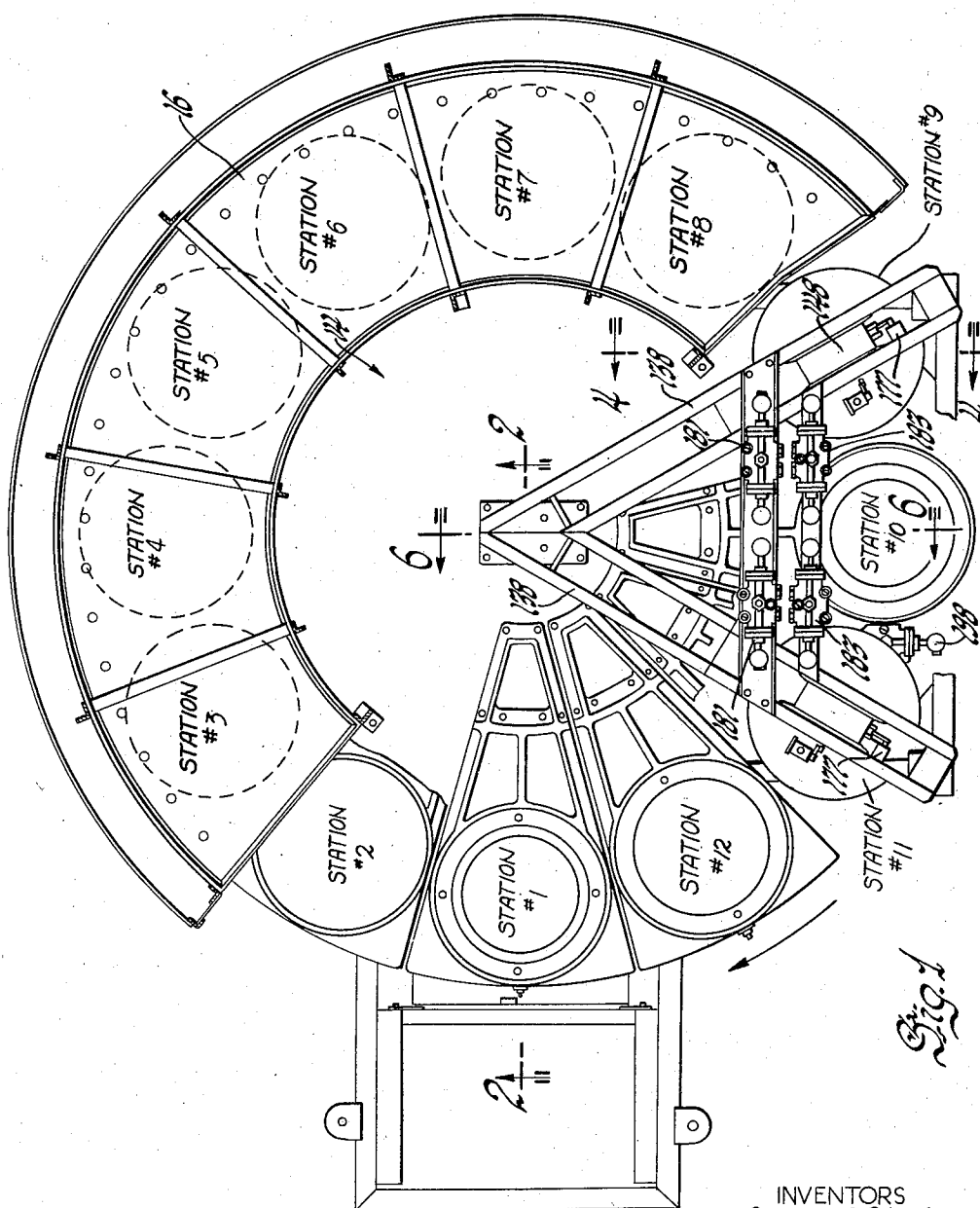
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G. A. ZINK ET AL
CORE MAKING APPARATUS

2,899,725

Filed June 29, 1956

5 Sheets-Sheet 1



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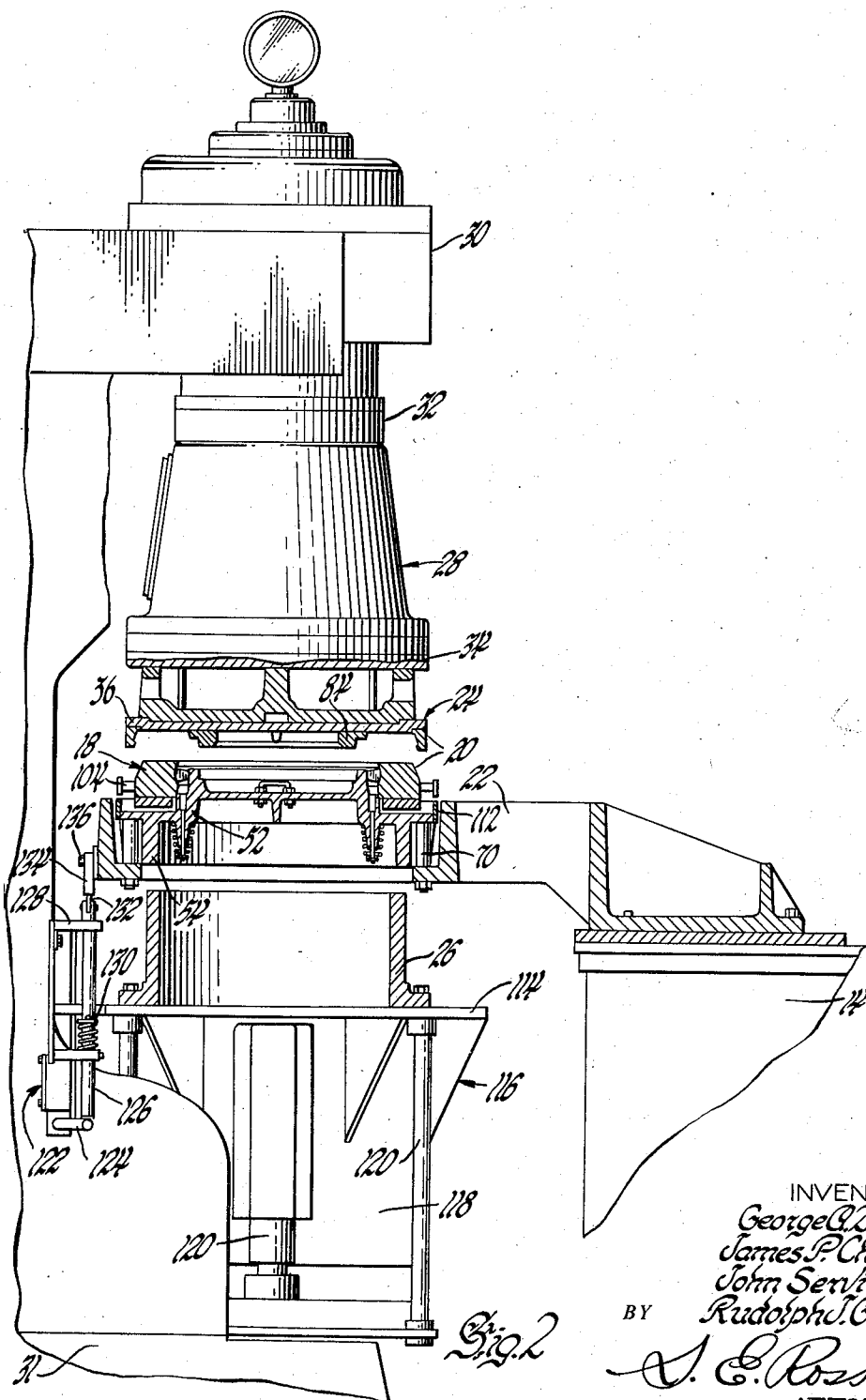
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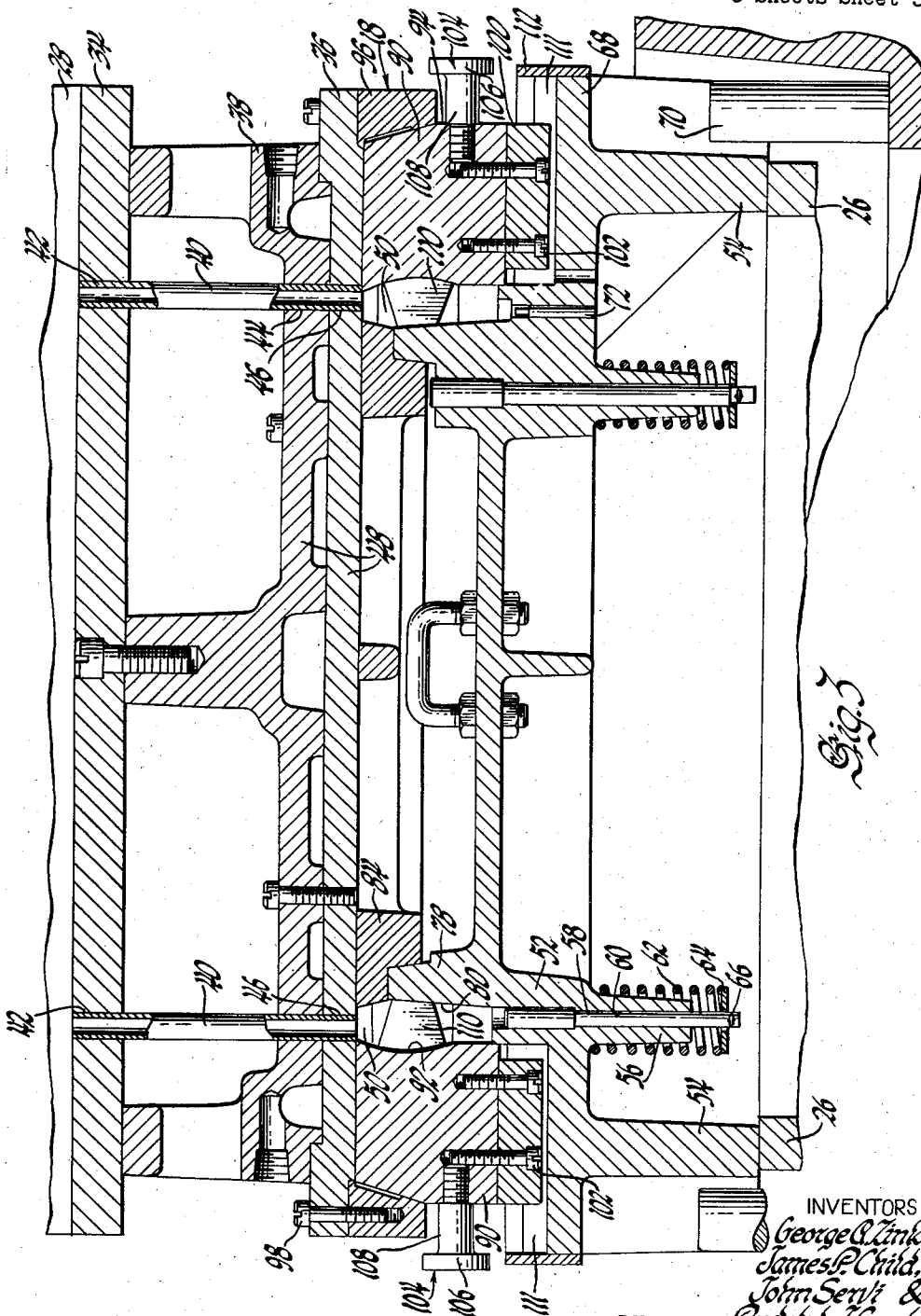
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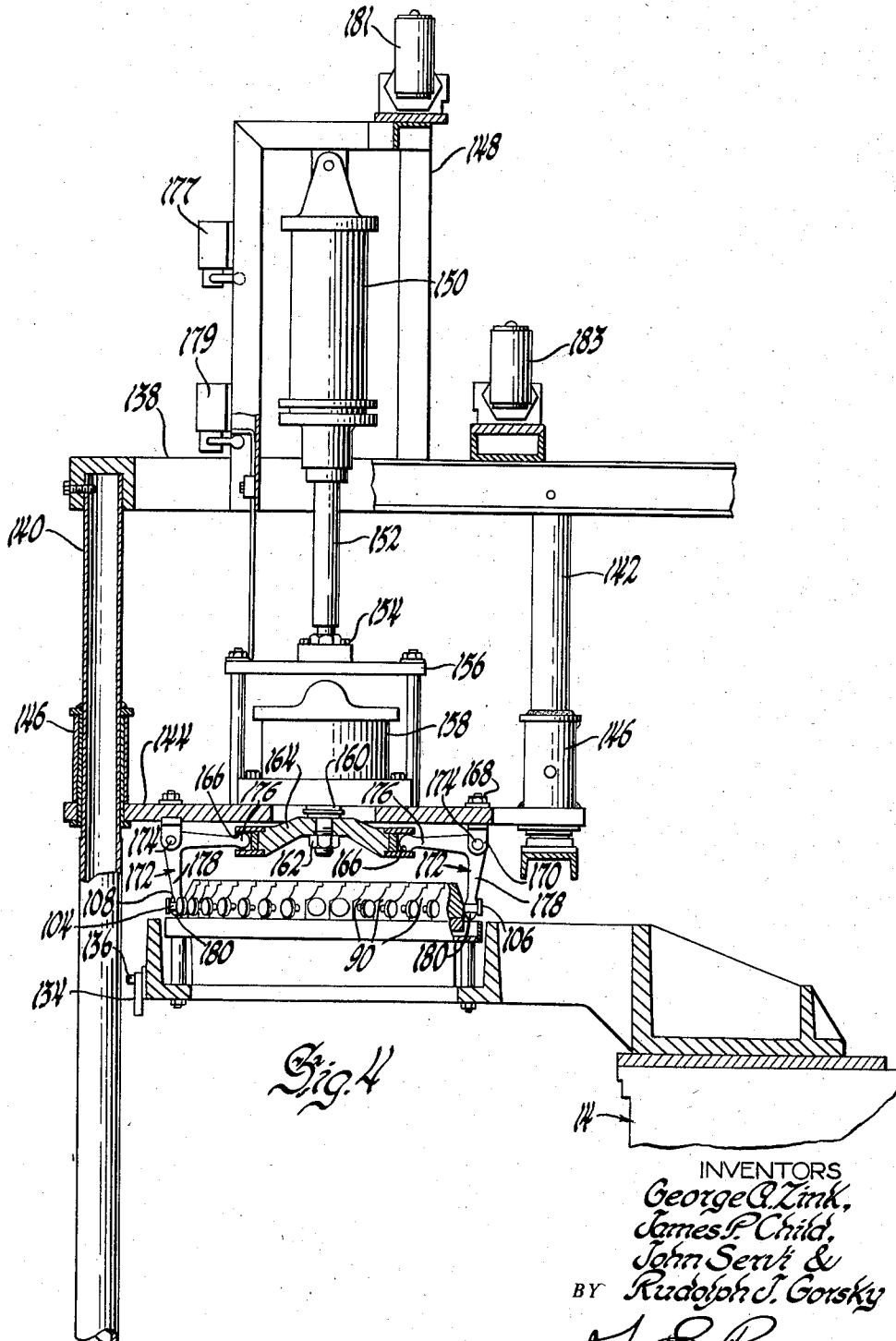


Fig. 4

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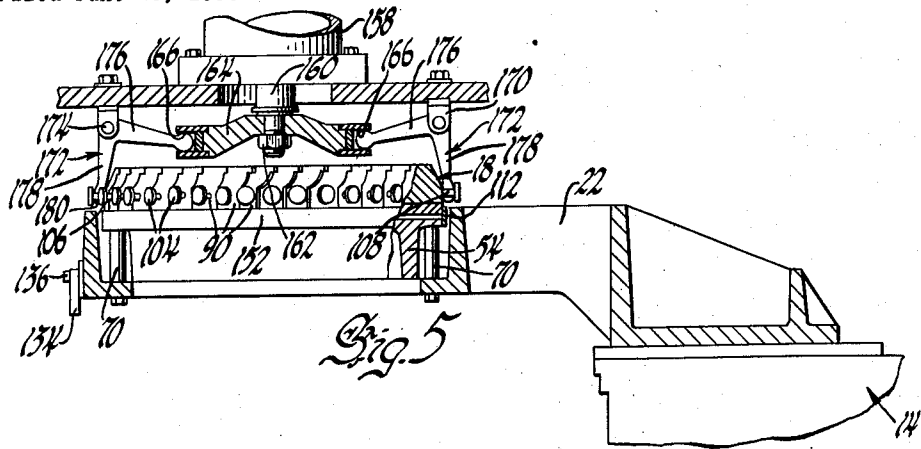
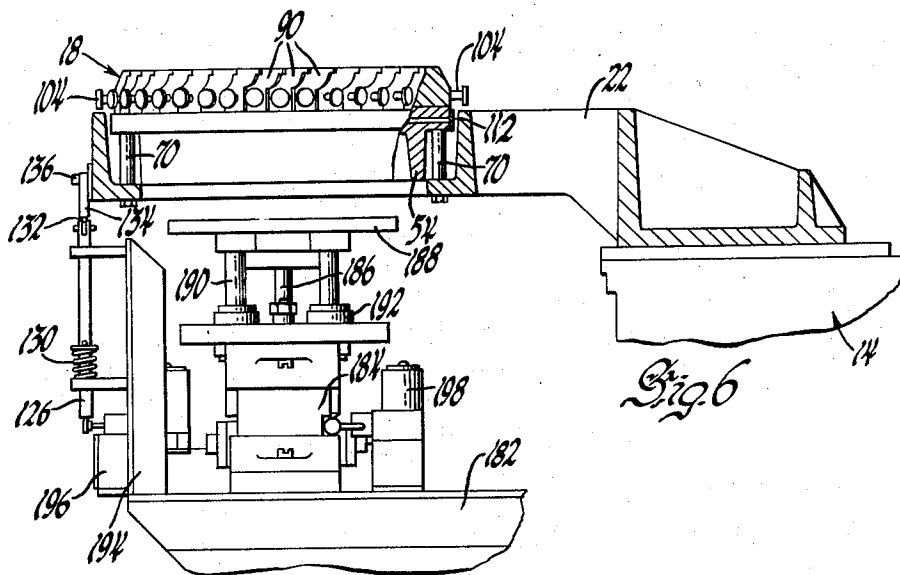
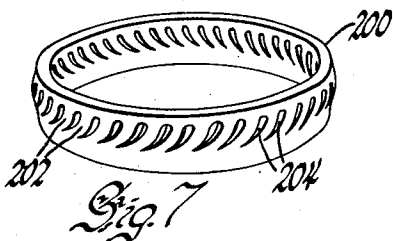
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2,899,725

CORE MAKING APPARATUS

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Application June 29, 1956, Serial No. 594,870

13 Claims. (Cl. 22—10)

This invention relates to a core making machine and particularly to an apparatus and process for forming one-piece, shell-type, sand-resin cores which are especially useful in casting annular turbine parts or the like.

As is now well known, the shell molding process involves the formation and use of thin-walled dispensable molds and cores composed of sand and resinous binders. This process can be used to produce precision castings in a wide variety of metals.

Heretofore, in the manufacture of cast annular parts, such as turbines and pumps of automatic transmissions for use in automotive vehicles, it has been common practice to employ a multiplicity of plaster cores in conjunction with mold members. Generally either a permanent or semi-permanent mold was used with the cope half thereof being formed of metal and the drag half being formed either of metal or sand. For example, a shell mold has been used as a drag half in combination with a plurality of small foam plaster cores. The central portion of each of these plaster cores has the same shape as the vanes in the turbine or pump to be cast. Although the use of a large number of separate cores frequently produced flash at the edge of the vanes, it had been considered necessary to employ these separate cores because of the difficulty encountered in forming a one-piece annular core due to the complex configuration of the vanes. The compound curvature of these vanes presented a problem with regard to removal of such a core from a core making machine.

Accordingly, a principal object of the present invention is to provide an apparatus and process for rapidly and conveniently forming inexpensive one-piece annular cores for use in casting ring-shaped vane members, such as turbine rings of an automatic transmission for motor vehicles. A further object of the invention is to provide a core making machine and process which produce accurate one-piece, annular, shell-type cores for precision casting of vane turbine or pump parts, whether used as rotors or stators.

Another object of this invention is to provide such a machine and process to produce a one-piece annular core of the aforementioned type which possesses good dimensional stability, satisfactory gas permeability, smooth surfaces and adequate strength. Such a core eliminates use of the relatively expensive foam plaster cores and the costly and time-consuming assembly thereof in a mold, thereby permitting the production of multi-vane turbine or pump parts in a much more rapid and inexpensive manner. Furthermore such castings, which generally are concentric rings connected by a multiplicity of radially extending vanes, have no flash at the edge of the vanes.

The shell molding process involves the use of a thermosetting plastic or resin as a binder for the grains of sand or other refractory material to form rigid molds having high gas permeability, good surface smoothness and dimensional stability. The molding material, which is gen-

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erally a mixture of a major proportion of silica sand and a minor proportion of resinous binder, is normally used in dry form with no water being added. With the apparatus and process hereinafter described, it is desirable to coat the sand particles with the thermosetting resin before the mixture is applied to the pattern or core box, rather than merely mixing the resin with the sand in powder form. Such a sand-resin mix normally contains between 1% and 8% by weight of binder, phenol formaldehyde and melamine formaldehyde resins being typical examples of thermosetting binders preferably used. A 1¼% to 5% phenol formaldehyde binder content is generally preferred.

Of course, it is usually advantageous to include in the mix an appropriate small amount of an accelerator or condensation agent for the binder, such as hexamethylenetetramine or paraformaldehyde. Under some circumstances it is also desirable to incorporate a mold release agent in the shell molding mix rather than spraying a lubricant onto the hot pattern between mold forming cycles. A suitable wax may be used for this purpose. Other substances, such as oleum fuel oil or kerosene, can be added in small amounts to increase the blowability of the mix when the molds or cores are being blown rather than dumped. Silica flour or other finely comminuted facing material also may be included in the molding mix to provide the cores with exceptionally smooth casting-defining surfaces.

These shell molds or cores are prepared by allowing the sand and resin to come into contact with a hot pattern or core box for a short period of time, usually from a few seconds to one minute. A generally uniform layer of the mix adheres to the pattern or core box surfaces due to the melting of the resin which bonds the sand with which it is intimately mixed, thereby accurately reproducing pattern details. The half pattern, gates and runners usually are permanently fixed on metal plates. Metal patterns and core boxes normally must be used because they are subjected to elevated temperatures. Pattern temperatures between 350° F. and 500° F. are generally preferred, but temperatures as low as 250° F. or lower and as high as 700° F. and even higher may be advantageously employed under particular conditions.

After formation of the mold or core in this manner, any excess molding mix is removed, and the sand-resin layer is preferably cured while in contact with the pattern or core box by subjecting the same to a temperature of approximately 300° F. to 1500° F. The curing or baking time is relatively short, usually from a few seconds to five minutes. This curing operation results in the conversion of the resinous material to a hard, insoluble binder which securely bonds the sand grains together. After curing of the mold or core, it is stripped from the pattern or core box and is ready for use.

The advantages inherent in the shell molding process are utilized in accordance with the present invention by the formation of one-piece annular cores which may be used in precision casting operations to eliminate the necessity of employing a multiplicity of separate cores, such as those heretofore formed of foam plaster. As indicated above, such one-piece cores find specific application in the casting of turbines for automatic transmissions of automotive vehicles.

Other objects and advantages of the present invention will more fully appear from the following detailed description of a preferred embodiment of the invention, reference being made to the accompanying drawing, in which:

Figure 1 is a somewhat schematic plan view of a shell core making apparatus embodying the invention;

Figure 2 is an enlarged vertical elevational view, with

parts broken away and in section, generally along the line 2—2 of Figure 1, showing the core blowing station of the apparatus illustrated in Figure 1;

Figure 3 is an enlarged vertical sectional view showing the details of the core box and blowhead shown in Figure 2;

Figure 4 is an enlarged vertical elevational view, with parts broken away and in section, generally along the line 4—4 of Figure 1, showing the mechanism used to form radially extending openings in the annular core;

Figure 5 is a fragmentary sectional view showing parts of the mechanism of Figure 4 in another operating position;

Figure 6 is an enlarged vertical elevational view, with parts broken away and in section, generally along the line 6—6 of Figure 1, showing the apparatus used to strip the cured core from the core box; and

Figure 7 is a perspective view of an annular shell core formed in accordance with the invention.

Referring more particularly to the drawings, in Figure 1 is shown an apparatus for forming a one-piece, multi-vaned shell core of annular shape for use in casting the first turbine of an automatic transmission. This apparatus includes twelve stations or positions at which core boxes are indexed during the shell core forming cycle. These core boxes are mounted on a turntable, indicated generally by 14, so that they revolve in a horizontal plane.

A core oven 16, which may be gas heated, electrically heated, or heated by other appropriate means, is located over approximately one-half of the stations of the turntable. In this manner, when the machine is being used at full capacity, six cores are being cured in the oven at any given time. As will be hereinafter more fully described, the other six stations are for blowing the cores, removing cured cores, etc.

It has been found desirable to employ a core-making cycle which is approximately four minutes in duration, a core box remaining at each station for approximately 20 seconds. Hence the oven curing time involved is approximately two minutes, the stations which are not located in the oven occupying the other two minutes time. These remaining six stations include a station for retracting opening-forming core box projections from the cured cores, a station for stripping each core from its core box, a station for moving the aforementioned projections back into core-forming position, a station for cleaning each core box and for applying a mold lubricant to its core-defining surfaces, a station for blowing the cores, and a station which is "blank" between the blowing station and the oven. This latter station is necessary because of the heat from the oven which, if it were located too close to the blowhead, would interfere with proper blowing operations by partially setting the resin binder in the mix.

It has been found preferable to heat the oven to a sufficient extent to cause each core box to reach a temperature of approximately 375° F. to 400° F. while in the oven and to have the turntable rotate at a rate which permits each core box to still have a temperature of about 350° F. to 375° F. when the sand-resin mix is again blown into it. An oven temperature between 500° F. and 600° F. has been found satisfactory for this purpose. With this arrangement the same baking operation serves to cure the shell core in each core box and also to heat the core box for the next core-forming cycle.

The turntable 14 rotates clockwise when viewed from above, as indicated by the arrow in Figure 1. At station No. 1 each rotatable drag half of the core box is moved vertically upward into abutment with the cope or blowhead half of the core box. Only one "cope half" is employed, and it is stationary, forming a permanent part of the core-blowing mechanism. Each core is blown at this first station, the blowhead and magazine for storing

the dry sand-resin mix being positioned above the drag halves when they are in this position. After each core is blown, the drag half of the core box beneath the blowhead is lowered back into position on the turntable.

Station No. 2 is the "blank" station previously referred to. Stations Nos. 3 through 8 are located within the curing oven 16, as shown in Figure 1. At station No. 9 the opening-forming members are retracted from each core box; while at station No. 10 an ejector plate is moved vertically upward to actuate spring-biased stripper pins located in the drag half of each core box, thereby lifting the cured core from the drag. At station No. 11 the opening-forming members are moved back into core-forming position, and at station No. 12 the core box is cleaned and lubricated with a mold release agent.

The core blowing station (station No. 1) is shown in Figure 2. It will be noted that each drag half 18 of the core box 20 is mounted on a radially extending platform or arm portion 22 of the turntable 14 so that these parts of the apparatus are rotatable in a horizontal plane between the blowhead or cope half 24 of the core box and the lift ring 26 of a generally conventional core blowing machine. The blowhead is affixed by suitable means to an upwardly tapered magazine 28 for containing a sand-resin molding mixture of the type hereinbefore described. This magazine is located beneath and communicates with an air supply means, indicated generally by 30, supported by the frame 31 of the core blower machine. The upper end of the magazine can be attached to the air supply means by means of a threaded collar 32, as shown, or it may be fastened thereto by bolts or other appropriate means. The magazine has its upper end provided with an opening, not shown, through which the sand-resin mix and compressed air may be introduced into the magazine. The lower end of the magazine is secured to the top wall or plate 34 of the blowhead.

When the drag half 18 of the mold is moved upward into contact with the cope half or blowhead 24 in the manner hereinafter described, the resultant core box assembly will be in condition to receive a fresh charge of the sand-resin mix. This assembly is shown in Figure 3 in position to receive such a charge, while in Figure 2 the cope and drag halves of the core box are shown as separated after the blowing operation. Air pressure in the range of approximately 120 p.s.i. to 150 p.s.i. has proved to be satisfactory.

As shown in Figure 3, the top plate 34 of the blowhead assembly is secured to and spatially separated from the bottom plate 36 thereof by means of a spacer frame 38. It will be seen that the bottom plate also functions as the cope half of the core box. However, unlike the drag half of the core box, plate 36, as well as the rest of the blowhead assembly, is unheated.

A plurality of blow tubes 40, which are preferably made of steel tubing, extend through the upper blowhead plate 34, the spacer frame, and lower blowhead plate 36. The upper ends of these blow tubes are press fitted into openings 42 which are drilled and countersunk in plate 34, while the lower ends of the blow tubes are similarly fitted into openings 44 and 46 in the bottom wall 48 of the spacer frame 38 and blowhead plate 36, respectively. The blow tubes conduct the sand-resin molding mix from the magazine 28 to a mold-forming cavity 50 formed between the plate 36 and the cooperating portions of the heated multi-piece drag half 18 of the core box. These blow tubes are located at appropriate positions to properly distribute the molding mix in the cavity. Of course, the locations of the blow tubes are dependent on the shape and size of the mold to be formed. It should be noted that the sand-resin molding mix from the magazine enters the cavity 50 in the core box through unheated blow tubes, thereby precluding the possibility of the mix fusing within these tubes and obstructing the passage of fresh molding mix therethrough. In order to further aid in preventing plugging of the blow tubes with

the molding material, the openings extending through these tubes may be upwardly tapered. At the same time, the lower ends of the blow tubes are preferably provided with internal threads to prevent the molding mix from continuing to pass through these tubes after each blowing operation.

The core box drag half 18, which is normally positioned on the radially extending platform portion 22 of the turntable 14, is shown as constructed of several parts. The base portion 52 has a downwardly extending annular flange 54 which rests on the upper edge of the lift ring 26 when the drag is lifted off the turntable. Depending projections or bosses 56 are also formed on the base of the core box. Mold ejector or stripper pins 58 are provided in the core box base plate 52 and are vertically slidable in openings 60 which extend through the bosses 56 and the portion of the plate 52 above these projections. Helical compression springs 62 are positioned around the bosses and bias the ejector pins in their lower or retracted positions. The lower ends of the springs abut washers 64 which are held in place at the bottom end of the ejector pins by means of cotter pins 66. Outwardly extending flanges 68 on the base plate 52 contact the upper ends of supporting pins 70 when the drag half of the core box is in its lowered position. These pins, which are secured to the turntable platform 22, support the drag half of the core box and maintain it in proper radial alignment when it is in its lowered position shown in Figure 2.

A plurality of vents 72 extend through the base plate 52 of the heated core box and provide communication between the core-defining cavity 50 and the atmosphere. These vents permit the escape of air displaced from the cavity 50 during core blowing operations. The outer peripheral surface 80 of the vertically extending annular wall portion 78 of the base plate constitutes the inner, cylindrical wall of the core-defining cavity 50. An annular ring member 84 is attached to the lower surface of the blowhead plate 36 and functions as a continuation of this wall when the cope and drag halves are in assembled position.

A plurality of retractible core box members or vane inserts 90 are provided radially outwardly of the cavity 50. The generally vertical inner surfaces 92 of these inserts constitute the outer walls of this cavity. It will be noted that the outer surfaces 94 of the retractible vane inserts are tapered slightly near their upper ends. When the drag half 18 of the core box is raised by means of the air cylinder hereinafter described and abuts the lower surfaces of the blowhead assembly 24, these tapered surfaces engage similarly tapered surfaces of a one-piece annular ring 96 which is secured by machine screws 98 to the lower blowhead plate 36 near its outer periphery. This engagement provides proper vertical alignment of the drag with respect to the blowhead. The ring 96 also retains the inserts in place radially during the blowing operation.

The retractible vane inserts 90 are shown in the drawings as being of a two-piece construction, a lower plate 100 being secured by machine screws 102 to the bottom of each of the principal portions of the inserts. Pins 104 are threaded into the outer surfaces of the vane inserts. These pins have enlarged outer end portions 106 and neck portions 108 between these ends and the outer walls of the inserts.

Each of the vane inserts is provided with an integral core opening-defining portion 110 which extends radially inwardly from the main body portion of the inserts. These opening-defining portions have the same shape as the vanes in the final casting. When the vane inserts are in their more radially inward position, the ends of the opening-defining portions contact the wall 80. On the other hand, when the inserts are retracted the opening-defining portions thereof are withdrawn to a sufficient

extent to permit the vertical removal of the cured annular core from the drag.

Of course, the guideways 111 in which the retractible vane inserts ride retain these inserts in proper position radially when they are being moved into and out of core-forming position. A flange or stop 112 is attached to and extends around the outer periphery of the base plate 52 of the core box. When the vane inserts 90 are retracted, this flange contacts the outer vertical surfaces of plates 100 to prevent the inserts from being withdrawn to too great an extent.

Referring back to Figure 2, it will be seen that the lift ring 26 is mounted on and secured to a platform portion 114 of a lift table 116 which is attached to the frame 31 of the core blowing apparatus. This platform constitutes the top of an air cylinder 118 which serves to raise and lower the lift ring. Vertically extending guide rods 120 for the platform are located adjacent the air cylinder.

A limit switch 122, which is secured to the frame 31, is provided with a switch arm 124. This switch arm contacts the lower end of a control rod 126 which is vertically slidable in a supporting bracket 128. A compression spring 130 tends to force the control rod upwardly so that a small wheel 132 secured to the upper end of the control rod contacts a cam plate 134 rotatably secured to the peripheral edge of the turntable platform 22 by a pin 136. When the cam forces the control rod downwardly the circuit is disconnected, and when the cam permits this rod to move upwardly the circuit is again actuated. The limit switch is normally in the closed position, and the station is inactive when the switch is open. Limit switches of this type are provided at each of stations Nos. 1, 9, 10 and 11. When in inoperative positions these limit switches prevent the core from being blown at station No. 1, the vane inserts 90 from being retracted at station No. 9, the cured core from being automatically lifted from the core box at station No. 10, and the cope and drag from closing at station No. 11.

In Figure 4 is shown the apparatus for radially moving the vane inserts 90 into and out of core-forming position. A mechanism of this type is located at each of stations Nos. 9 and 11. As hereinbefore indicated, at station No. 9 the vane inserts are retracted so that the cured core may be removed from the heated core box at station No. 10. On the other hand, at station No. 11 the vane inserts 90 are forced radially inwardly into their core opening-defining positions preparatory to lubricating the hot core box at station No. 12 and to blowing the shell molding mix into the core box at station No. 1.

It will be seen that the apparatus shown in Figure 4 has upper horizontal frame members 138 which are supported by vertically extending tubular frame members 140. Connected to the horizontal frame members and depending therefrom are a pair of vertical guide bars 142. A horizontal platform 144 is affixed to sleeves 146 which are provided around the vertical frame members 140 and the guide bars 142. The sleeves are vertically slidable on these supporting parts, thereby permitting the platform 144 to be raised and lowered.

Attached to the horizontal frame members 138 is a suitable frame construction 148 which supports a hydraulic or air cylinder 150. This cylinder contains a piston 152 which is vertically slidable within the cylinder and is actuated by fluid under pressure. A collar 154 is shown as connecting the lower end of the piston 152 to structural members 156 secured to the platform 144. With this arrangement reciprocation of the piston within the cylinder serves to raise and lower the platform.

Located on the upper surface of the platform 144 and affixed thereto by screws or other suitable means is a second hydraulic or air cylinder 158 which is likewise provided with a piston 160 vertically reciprocable therein.

The lower end of this piston is connected by a nut and bolt assembly 162 to a generally laterally extending bracket 164, the periphery of which is provided with a horizontally disposed, annular recess or groove 166. Attached to the bottom surface of the platform 144 by suitable bolt and nut assemblies 168 are a plurality of downwardly extending U-shaped brackets 170. L-shaped levers 172 are pivotally secured within the brackets 170 by means of pins 174. Each of these levers has an inwardly extending arm 176 and a generally downwardly extending arm 178 having a bifurcated end 180. The ends of the horizontal arms engage the groove 166 in the bracket 164, while the bifurcated ends of the arms 178 are engageable with the neck portions 108 of the pins 104.

Thus it will be seen that when the plunger or piston 152 is forced downwardly within the cylinder 150 at station No. 9, it lowers the platform 144, which was originally in its elevated position, and causes the bifurcated ends of lever arms 178 to engage the neck portions 108 of the pins 104. Subsequent downward movement of the piston 160 within the cylinder 158 lowers the bracket 164 and the ends of lever arms 176. The resulting pivotal movement of the levers 172 causes the arms 178 to rotate outwardly. Since the bifurcated ends of these arms engage the necks 108 of the pins 104 and are prevented from sliding off these pins by the enlarged end portions 106, the movable vane inserts 90 are retracted radially so that the core-defining portions 110 thereof are withdrawn from the formed core. The locations of the piston 160 and the levers 172 when the inserts 90 are in this retracted position are shown in Figure 5.

Subsequent upward movement of the piston 152 raises the platform 144, bringing the lever arms 178 out of contact with the insert pins 104. This permits the turntable 14 to be rotated 30° to transfer the particular core box drag under consideration to station No. 10. At this station, with the vane inserts still in their retracted positions, the ejector pins 58 are moved upwardly, as hereinafter described. In this manner these pins lift the cured shell core off the heated core box plate 52.

After removal of the cured core from the core box at station No. 10, the turntable is again rotated 30° to transfer the core box drag to station No. 11. As indicated above, the apparatus shown in Figures 4 and 5 is located at this station as well as at station No. 10. Of course, the purpose of station No. 11 is to return the vane inserts to their mold-forming positions rather than to retract them. Accordingly at this station the platform 144 is initially in its upper position and the piston 160 is in its lower position. The platform 144 is first moved downward by means of piston 152, bringing the lever arms 178 into contact with the necks 108 of the vane insert pins 104. The piston 160 is next raised to pivot the levers 172 in a direction opposite from that described above and force the vane inserts radially inwardly back into their core-forming positions, as shown in Figure 5.

Of course, the operation of the apparatus shown in Figure 4 and 5 is reversed after each of the above-described procedures at stations Nos. 9 and 11. In this manner each of these mechanisms is in condition to repeat the process in the next core-forming cycle. Hence at station No. 9 the piston 160 is raised and the L-shaped levers 172 are pivoted to the positions shown in Figure 4 before the next drag is indexed at that station or while this indexing is taking place. Likewise, at station No. 11 the platform 144 is elevated and the piston 160 is lowered after the operation described above. Thus at this station the levers 172 are returned to the positions shown in Figure 5 and are in condition to actuate the retracted vane inserts 90 in the next drag.

Suitable limit switches 177 and 179 to control the operation of the mechanism shown in Figure 4 are attached to the frame 148 and are connected to valve

operating solenoids 181 and 183. Solenoid 181 controls the operation of the cylinder 150 which solenoid 183 controls the operation of the cylinder 158.

The mechanism located at station No. 10 for stripping the cured core from the core box is shown in Figure 6. This apparatus includes a base 182 which supports a suitable air or hydraulically operated cylinder 184 positioned beneath the horizontal platform or arm portions 22 of the turntable. Within this cylinder is a vertically aligned piston or plunger having an upwardly extending arm 186 attached to a stripper plate 188. Vertical guide rods 190 are connected to the bottom of the stripper plate and are slidable within a housing 192 which partially surrounds the cylinder 184. These guide rods maintain the stripper plate in a level position and prevent it from rotating. Thus it will be seen that upward movement of the piston within the cylinder forces the stripper plate to contact the lower ends of the stripper pins 58 and move these pins upwardly. This movement of the stripper pins lifts the cured core off the base plate 52 and permits it to be readily removed from the core box.

A limit switch 196 of the type hereinbefore described is connected to a vertical frame member 194 attached to the base 182. This limit switch and the associated mechanism are the same type described above, and hence the same reference numerals are applied to similar parts. The switch is connected to a solenoid operated valve 198 which controls the movement of the piston within the cylinder 184.

From the above description it will be seen that the sequence for forming the annular one-piece core is as follows. The heated drag half 18 of the core box, which is supported on the horizontal platform portion 22 of the turntable, is rotated into position beneath the core blower 28, as shown in Figure 2. Thereafter the air cylinder 118 raises the lift ring 26 so that its upper edges contact the vertically aligned flanges 54 on the bottom of the drag. In turn the drag is elevated into engagement with the blowhead 24, thereby forming a complete core box assembly. Sand-resin molding mix is then blown from magazine 28 through blow tubes 40 into the core-defining cavity 50 in the core box. Since the drag is at an elevated temperature, the resinous binder partially sets and bonds the sand particles together. Thereafter the lift ring 26 is moved downwardly by means of the air cylinder 118, lowering the drag back onto the platform portion 22 of the turntable.

The turntable is then rotated clockwise, as viewed in Figure 1, in increments of 30°. Station No. 2 is a blank station, as explained above. At stations Nos. 3 through 8 the sand-resin core is heated in the oven 16 so that the core is cured when it reaches station No. 9.

At station No. 9 the vane inserts 90 are retracted by means of the mechanism shown in Figures 4 and 5. The operation of this apparatus was hereinbefore described in considerable detail. Thereafter the hot drag half of the core box, with the vane inserts in their retracted positions, is moved to station No. 10. At this station the air cylinder 184 elevates the stripper plate 188 into contact with the ejector pins 58 and raises these pins to lift the cured shell core off the drag. The core may then be removed from the core box and placed on a suitable conveyor.

The drag half of the core box, which is still at an elevated temperature, is next rotated 30° to station No. 11 where the vane inserts 90 are returned to mold-forming position by the above-described operation of the mechanism shown in Figure 4. Then the drag is moved to station No. 12 where any loose molding material is blown from the core box and the core box is sprayed with a suitable mold release agent or lubricant. The particular core box under consideration thus has completed its mold-forming cycle and is in condition to be again moved to station No. 1 to receive the next charge of molding mix.

It will be understood, of course, that a drag half of the

core box is located at each station at all times. It also will be noted that stations Nos. 11 and 12 are the only ones at which the cores are not located at any time. Hence when the annular shell core-forming apparatus is being used at full capacity, ten cores are being treated simultaneously.

A one-piece annular shell-type core 200 which may be formed by the above-described process is shown in Figure 6. This type of vane core ring may be used in casting the vanes of an automatic transmission turbine. When the cured core has cooled, it is preferably placed in a permanent mold, and the molten metal which is poured into the mold fills the radially extending openings 202 in the vane core ring. After the solidified casting has been removed from the mold, the shell core which has been surrounded by the hot metal is easily crumbled from the casting, leaving clean passages between the turbine vanes.

As hereinbefore indicated, the core assembly previously used for forming such turbine parts consisted of a multiplicity of small plaster vane cores which had to be individually placed in the mold. It will be noted that as many plaster cores were required as the number of core portions 204 between the vane-defining openings 202 in the one-piece core shown in Figure 6. Moreover, with processes heretofore used, the annular castings had parting lines or fins along the leading and trailing edges of the vanes. These fins, which were located at the junctions of the vane core segments, tended to reduce the operating efficiency of the turbine. On the other hand, a casting produced by the one-piece shell molded core described above has no parting lines on the vanes. Moreover, the use of this core substantially reduces the cost of the casting since it is unnecessary to assemble a large number of separate core segments.

Various modifications in the arrangement and details of the specific embodiment described and shown herein will be apparent to those skilled in the art and are contemplated as within the scope of the present invention as defined in the appended claims.

We claim:

1. An apparatus for forming shell cores, said apparatus comprising a horizontally rotatable turntable, a magazine for containing a mixture of sand and thermosetting binder located above a portion of said turntable, a blowhead attached to the outlet end of said magazine, a plurality of core boxes supported on said turntable and successively rotatable therewith into position beneath said blowhead, said core boxes each being provided with a plurality of radially movable inserts each having a portion shaped to define openings in a core, means for heating said core box, a plurality of arms actuated by a fluid-operated piston for moving said inserts radially inward into core-forming position and radially outward out of core-forming position, and means for blowing said mixture from said magazine into said core boxes.

2. An apparatus for forming annular shell-type cores, said apparatus comprising a horizontally rotatable turntable, a magazine for containing a mixture of sand and thermosetting binder located above a portion of said turntable, a blowhead attached to the lower end of said magazine, a plurality of core boxes supported on said turntable and successively rotatable thereby into position beneath said blowhead, means for heating said core boxes, said core boxes each being provided with a plurality of slidable inserts each having an inner portion shaped to define radial openings in a core, a plurality of arms adapted to alternately engage and disengage said inserts to slide said inserts into and out of core-forming position, means for moving said core boxes into engagement with said blowhead, means for blowing said mixture from said magazine through said blowhead into said core boxes, and a curing oven located over a portion of said turntable and core boxes.

3. An apparatus for forming annular shell cores, said apparatus comprising a horizontally rotatable turntable,

a stationary frame construction, a magazine for containing a mixture of sand and thermosetting resin binder located above a portion of said turntable, a blowhead attached to the lower end of said magazine, a vertically reciprocable lift table positioned beneath said blowhead and spatially separated therefrom, a plurality of core boxes supported on said turntable and rotatable therewith into position between said blowhead and said lift table, means for heating said core boxes, said core boxes each being provided with a plurality of horizontally slidable inserts each having an outer neck portion and an inner portion extending radially inward into a core-forming cavity defined by said inserts, a plurality of levers connected to said frame construction each having an arm adapted to alternately engage and disengage one of said neck portions, means for moving said arms into and out of engagement with said neck portions, means for pivoting said arms to thereby radially slide said inserts into and out of core-forming position when engaged by said arms, means for blowing said mixture from said magazine into said core boxes, a curing oven located over a portion of said turntable and core boxes, and a vertically movable stripper plate located beneath a portion of said turntable for lifting cured shell cores from said core boxes as said core boxes are successively rotated on said turntable to a location above said stripper plate.

4. An apparatus for forming one-piece annular shell-type cores, said apparatus comprising a horizontally rotatable turntable, a stationary supporting frame, a magazine for containing a mixture of sand and thermosetting resin binder located above a portion of said turntable, an unheated blowhead attached to the lower end of said magazine, a vertically reciprocable lift table positioned beneath said blowhead and spatially separated therefrom, a plurality of core boxes supported on said turntable and rotatable therewith into position between said blowhead and said lift table, means for heating said core boxes, said core boxes each being provided with a plurality of horizontally slidable and annularly arranged wedge-shaped inserts each having a radially extending outer neck portion and an inner portion adapted to extend radially inward into a core-forming cavity defined by said inserts, a fluid-operated piston supported by said frame, a platform connected to said frame and said piston whereby movement of said piston vertically reciprocates said platform, a second fluid-operated piston supported by said platform, a plurality of levers pivotally secured to said platform, each of said levers having an arm operatively connected to said second piston and a free arm adapted to engage one of said neck portions upon lowering of said platform, said second piston being vertically reciprocable to pivot said levers and thereby slide said inserts horizontally when engaged by said arms, means for blowing said mixture from said magazine into said core boxes, an oven located over a portion of said lift table and core boxes for curing said cores while in said core boxes, and a vertically movable stripper plate located beneath said turntable for lifting cured shell cores from said core boxes as said core boxes are successively rotated on said turntable to a location above said stripper plate.

5. An apparatus for forming an annular shell core, said apparatus comprising a base member, a plurality of radially slidable inserts positioned on said base member and defining a core-forming cavity therewith, each of said inserts having an inner portion adapted to project radially inward into said cavity, a plurality of arm members for alternately engaging and disengaging said inserts, means for moving said arm members into and out of engagement with said inserts, and means for moving said arms radially to thereby slide said inner portions radially inward into said cavity and radially outward out of said cavity when said inserts are engaged by said arms.

6. An apparatus for use in forming a shell core, said apparatus comprising a base member, a plurality of wedge-shaped inserts slidably positioned on said base member and defining an annular core-forming cavity

therewith, means for heating said base member and said inserts each of said inserts having an outer neck portion and an inner portion adapted to project radially inward into said cavity to define radially extending openings in a core formed therein, a plurality of levers each having an arm for alternately engaging and disengaging one of said neck portions, means for vertically moving said arms into and out of engagement with said neck portions, and means for pivoting said levers to thereby slide said inner portions radially inward into said cavity and radially outward out of said cavity when said neck portions are engaged by said arms.

7. An apparatus for forming a one-piece annular shell core, said apparatus comprising a metal base member, a plurality of radially movable metal vane inserts slidably positioned on said base member and defining a core-forming cavity therewith, means for heating said base member and said inserts, each of said inserts having an inner portion adapted to project radially inward into said cavity to define circumferentially spaced radially extending openings in a core formed therein, a support mounted above said inserts, means for moving said support in a vertical direction, a vertically reciprocable piston attached to said support, and a plurality of levers pivotally secured to said support, said levers each having an arm engageable with one of said inserts and a second arm operatively connected to said piston whereby reciprocation thereof pivots said levers and slides said inserts radially inward into said cavity and radially outward out of said cavity when engaged by said levers.

8. An apparatus for use in forming an annular shell core, said apparatus comprising a metal base member, a plurality of radially movable metal inserts slidably positioned on said base member and defining a core-forming cavity therewith, means for heating said base member and said inserts, each of said inserts having an outer neck portion and an inner portion adapted to project radially inward into said cavity to define a radially extending opening in a core formed therein, a support member mounted adjacent said inserts and vertically movable relative thereto, a vertically reciprocable piston attached to said support, and a plurality of levers pivotally secured to said support, each of said levers having a pair of arms, one of said arms being engageable with one of said neck portions, the other of said arms being operatively connected to said piston whereby reciprocation thereof pivots said levers and horizontally slides said inserts radially inward into said cavity and radially outward out of said cavity when engaged by said levers.

9. An apparatus for forming a one-piece annular shell core for use in casting a multi-vaned turbine ring or the like, said apparatus comprising a frame, a fluid-operated piston carried by said frame, a platform connected to said frame and said piston whereby movement of said piston vertically reciprocates said platform, a second fluid-operated piston supported by said platform, a metal plate member located beneath said platform, a plurality of wedge-shaped metal inserts annularly arranged on said plate member and horizontally slidable thereon in a radial direction with respect to said plate member, means for heating said plate member and said inserts, said inserts and said plate member jointly defining an annular core-forming cavity, each of said inserts being provided with a radially extending outer neck portion and an inner portion adapted to extend radially inward into said cavity to define a radial opening in a core formed in said cavity, a plurality of levers pivotally secured to said platform, each of said levers having an arm operatively connected to said second piston and a free arm having a bifurcated end adapted to engage one of said neck portions upon lowering of said platform, said second piston being vertically reciprocable to pivot said arms and thereby slide said inserts horizontally when said levers engage said inserts.

10. An apparatus for forming a shell core, said apparatus comprising a magazine for containing a mixture

of sand and thermosetting binder, a blowhead attached to the outlet end of said magazine and constituting the cope half of a core box, a drag half of said core box positioned beneath said cope half, said drag half having an inner stationary core-defining member and a plurality of radially slidable opening-forming metal members positioned outwardly of said inner stationary member and arranged annularly to define an interjacent annular core-forming cavity with said stationary member, and arms actuated by a fluid-operated piston for moving said opening-forming members radially inward into core-forming position in said cavity and radially outward to withdraw said opening-forming members from said cavity, said cope half being provided with a plurality of blow tubes extending generally vertically from said magazine to a core-defining cavity between said radially slidable members and said inner stationary member.

11. In an apparatus for forming a one-piece annular shell core provided with a plurality of radially extending openings, a magazine for containing a mixture of sand and a thermosetting plastic binder, a blowhead assembly secured to the outlet end of said magazine, said assembly comprising a horizontal plate spatially separated from said magazine and a plurality of tubular ducts extending from said magazine through said plate, an inner core-defining metal core box member positioned beneath said assembly, a plurality of metal opening-defining core box members located outwardly of said inner member and radially slidable relative thereto, means for heating said core box members, the upper surfaces of said inner member and said opening-defining members being adapted to contact said plate, said core box members and said plate defining an annular core-forming cavity therebetween, said ducts communicating with said cavity, and a plurality of retractable pins extending through said inner core box member for stripping the formed core therefrom.

12. In an apparatus for forming a one-piece annular shell core having openings radially extending there-through, the combination of a magazine for containing a dry molding mixture of sand and a thermosetting resin binder, a blowhead attached to the outlet end of said magazine, a metal core box relatively reciprocable into and out of proximity to said blowhead, said core box comprising a stationary metal plate having wall portions for forming inner vertical and lower horizontal surfaces of the core to be formed and a plurality of metal inserts positioned radially outwardly of said inner vertical surfaces and radially slidable relative thereto, means for heating said core box, said inserts being provided with core opening-forming portions extending radially inwardly into proximity to said inner vertical surfaces, said core box and said blowhead defining an interjacent annular core-forming cavity having a depth equal to the thickness of the core to be formed, blow tubes located in said blowhead for conveying said molding mixture from said magazine to said cavity, said core box being provided with air vents for permitting the escape of air displaced from said cavity by the molding mixture entering therein, and a plurality of spring-biased pins extending through said plate for stripping the formed shell core therefrom.

13. A process for forming a one-piece annular shell core having a plurality of radially extending openings on its outer surface, said method comprising heating a core box, moving opening-defining portions of said core box radially inward into core-forming position, applying a release agent to the core-forming cavity of said heated core box, moving said heated core box into contact with the outlet end of an unheated blowhead, blowing a molding mixture of sand and thermosetting resin binder from a magazine through blowholes in said blowhead into a cavity defined by the blowhead and the core box so as to fully occupy said cavity and to force air from said cavity through openings in said core box, thereafter moving said core box out of engagement with said blowhead, curing the formed shell core by further heating it in an oven

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at a temperature between 300° F. and 1500° F. while in contact with said core box, subsequently moving said opening-defining portions of said core box radially outwardly from said cavity, and thereafter moving a stripper plate into contact with ejector pins in said core box to thereby strip the cured shell core from said core box.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,899,725

August 18, 1959

George A. Zink et al

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 46, for "one-pie" read -- one-piece --; column 7, line 60, for "Figure" read -- Figures --; column 8, line 2, for "which" read -- while --; column 10, line 29, for "superting" read -- supporting --; line 30, for "said" read -- sand --.

Signed and sealed this 22nd day of March 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents